| | Type | Hits | Search Text | DBs | Time Stamp |
|---|---|---|---|---|---|
| 1 | BRS | 2263 | selectively with (control or adjust) same gas and (thermal or heating or rtp or heat) | USPAT; US-PGPUB | 2002/12/30 13:22 |
| 2 | BRS | 501 | (selectively with (control or adjust) same gas and (thermal or heating or rtp or heat)) and (wafer or substrate) | USPAT; US-PGPUB | 2002/12/30 13:23 |
| 3 | BRS | 31 | ((selectively with (control or adjust) same gas and (thermal or heating or rtp or heat)) and (wafer or substrate)) and lamps | USPAT; US-PGPUB | 2002/12/30 13:23 |

US-PAT-NO: 6331212

DOCUMENT-IDENTIFIER: US 6331212 B1

TITLE: Methods and apparatus for thermally processing wafers

---------- KWIC ---------

High temperature processing of semiconductor wafers is essential to modern microelectronic device manufacturing. These processes include chemical vapor deposition (CVD), silicon epitaxy, silicon germanium, and rapid thermal processes (**RTP**) such as implant annealing, oxidation and diffusion drive-in. These are performed at temperatures ranging from about 400 to 1200 degrees Celsius in multi-wafer batch reactors, mini-wafer batch reactors, or in single wafer rapid thermal reactors. Numerous standard textbooks and references exist that described elevated temperature processing of semiconductor wafers. Some example references include Peter Van Zant, "Microchip Fabrication" 3rd edition, McGraw-Hill, New York, 1987; John L. Vossen and Werner Kern, "Thin Film Processes," Academic Press, Orlando, 1978; S. M. Sze, "VLSI Technology," McGraw-Hill, New York, 1988.

To meet these requirements, the industry has developed different approaches. One is a reduced batch size furnace with increased spacing between the wafers, thus allowing faster load/unload times with better process uniformities on the wafers. Another technique is the use of **RTP** systems which process one wafer at a time and typically uses high intensity quartz halogen lamps as a heat source. They can rapidly heat the wafer at up to 150.degree. C./sec to temperature ranges from about 400.degree. C. to 1200.degree. C. **RTP** cuts the cycle time by an order of magnitude or more, reduces the time at temperature, and eliminates dopant diffusion problems. With the improvement in process

uniformities the **RTP** systems produce, **RTP** effectively competes with the furnaces.

In a typical **RTP** system, the lamps are positioned in optical reflectors at a distance outside of a process chamber that is made of clear fused quartz. The clear fused quartz allows most of the lamp energy to pass through the process chamber to heat the wafer and wafer holder. However, the quartz chamber absorbs some of the energy from the lamps as well as radiation from the wafer and holder. The process chamber must be kept cool to prevent unwanted deposits from coating the process chamber walls. A coating on the processing wall interferes with the radiant energy transfer to the wafer; also, the coating can produce unwanted particles that can get onto the wafer. The wafer edges are close to the cooled wall and this can cause slip and process problems. Due to the cold wall requirement, growth rates using silicon gases are limited so as to minimize the deposits on the process chamber walls. For applications using silane, the growth rate is limited to only about 0.2 microns/minute.

Referring now to FIG. 5 wherein there is shown a view of an example of a gas injector 178 for process gas and purge gas flows to process chamber 54. Gas injector 178 includes three sections: process gas sections 182a and 182b for carrying process gas and a purge gas section 186 for carrying purge gas. Each section has a plurality of holes 189. In a preferred embodiment, the holes are substantially parallel within a section. The holes distribute the process gas so that the direction of the gas flow is substantially parallel to the plane of the wafer holder. In other words, a showerhead type of gas flow is directed approximately parallel to the wafer surface. As a further embodiment, gas injector 178 is arranged so that the gases can be **selectively** distributed across the wafer independently or together so as to obtain improved process uniformity **control**. Improved uniformity is obtainable by selectively distributing the gas across the wafer to compensate for variations in reaction rate caused by thermal gradients and gas flow.